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OF THE UNITED STATES
DEPARTMENT OF ENERGY



AN AERIAL RADIOLOGICAL SURVEY OF THE AREA SURROUNDING THE

MALLINCKRODT NUCLEAR MARYLAND HEIGHTS FACILITY AND TWO ADDITIONAL SITES

ST. LOUIS, MISSOURI

DATE OF SURVEY: OCTOBER 1977

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L. K. Hilton
Project Scientist

APPROVED FOR PUBLICATION

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ABSTRACT

An aerial radiological survey to measure terrestrial gamma radiation was carried out over the Mallinckrodt Nuclear Maryland Heights Facility during October 1977.

At the same time the following properties were also surveyed: a parcel near 9200 West Latty Avenue, which included a portion of St. Louis International Airport; and land used by West Lake Landfill, Inc., which is 8 km northwest of the airport.

Gamma ray data were collected by flying parallel lines 60 m apart. The total area surveyed over the three sites was 7.4 km².

Processed data indicated that detected radioisotopes and their associated gamma ray exposure rates were consistent with those expected from normal background emitters, except at certain locations described in this report.

Average exposure rates 1 m above the ground, as calculated from aerial data, are presented in the form of an isopleth map. No ground sample data were taken at the time of the aerial survey.

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Figure 1. FLIGHT LINES: MALLINCKRODT NUCLEAR



Figure 1. FLIGHT LINES: MALLINCKRODT NUCLEAR SITE

1.0 INTRODUCTION

The United States Department of Energy (DOE) maintains an aerial surveillance operation called the Aerial Measuring System (AMS).^{*} AMS is operated for DOE by EG&G. This continuing nationwide program, started in 1958, involves surveys to monitor radiation levels in and around facilities producing, utilizing, or storing radioactive materials. The purpose of the survey is to document, at a given point in time, the location of all areas containing gamma emitting radioactivity (visible at the surface), and to aid local personnel in evaluating the magnitude and spatial extent of any radioactive contaminants released into the environment. At the request of DOE, or other federal and/or state agencies (such as the United States Nuclear Regulatory Commission), AMS is deployed for various aerial survey operations.

AMS was utilized during the period 22-28 October 1977 to radiometrically survey an area 1.6 km² centered on the Mallinckrodt Nuclear Maryland Heights Facility. Also surveyed was an area 3.2 km² surrounding 9200 West Latty Avenue, which included a portion of the St. Louis International Airport. A third site surveyed was a 2.6 km² area centered on property operated by West Lake Landfill, Inc., 8 km northwest of the airport.

The St. Louis International Airport was the survey base of operation.

2.0 SURVEY AREA HISTORY AND LOCATION

The Mallinckrodt Nuclear Maryland Heights Facility is located at 2703 Wagoner Place, St. Louis, Missouri. This plant receives radioisotopes from various vendors and converts them to radio pharmaceutical materials. Radioisotopes which they handle include ¹³¹I, ^{99m}Tc, ⁹⁹Mo, ⁷⁵Se, and ⁵⁹Fe. Mallinckrodt Nuclear is a Division of Mallinckrodt, Inc. (formerly, Mallinckrodt Chemical Works). Mallinckrodt, Inc. acquired the Maryland Heights facility from Nuclear Consultants, Inc. in 1965.

It is reported in an ORNL report² and a NRC report³ that during the period 1942 through the late 1950's Mallinckrodt Chemical Works of St. Louis processed uranium ore. Some of the ore

residues and processed wastes were stored on the airport property.

In early 1966 these ore residues and uranium-bearing processed wastes were moved from the airport property by the Continental Mining and Milling Company of Chicago, Illinois to the Latty Avenue site.

In January, 1967 the Commercial Discount Corporation of Chicago, Illinois purchased the residues; much of the material was then dried and shipped to the Cotter Corporation facilities in Canon City, Colorado. The source material remaining at the Latty Avenue site was sold to the Cotter Corporation in December, 1969. Records indicate that residues remaining on the site at that time included 74,000 tons of Belgian Congo pitchblende raffinate containing about 113 tons of uranium; 32,500 tons of Colorado raffinate containing about 48 tons of uranium; and 8,700 tons of leached barium sulfate containing about 7 tons of uranium. During the period August through November, 1970 Cotter Corporation dried some of the remaining residues and shipped them to their mill in Canon City, Colorado. By December, 1970 an estimated 10,000 tons of Colorado raffinate and 8,700 tons of leached barium sulfate remained at the Latty Avenue site.

In April, 1974 a NRC inspector was informed that the remaining Colorado raffinate had been shipped in mid-1973 to Canon City without drying and that the leached barium sulfate had been transported to a landfill area in St. Louis County. A reported 12 to 18 inches of topsoil had been stripped from the Latty Avenue site; this supposedly had been removed with the leached barium sulfate. However, analyses of soil samples taken during a NRC investigation of the Latty Avenue site in 1976 indicated the presence of uranium- and thorium-bearing residues.

The West Lake Landfill property is located off St. Charles Rock Road near Taussig Road, approximately 8 km northwest of the airport.

3.0 SURVEY METHOD AND AIRBORNE EQUIPMENT

An enlarged aerial photo of each site was used to lay out the survey flight lines (Figures 1, 2, and 3). The navigator visually directed the aircraft

^{*}Formerly Aerial Measuring System (ARMS).

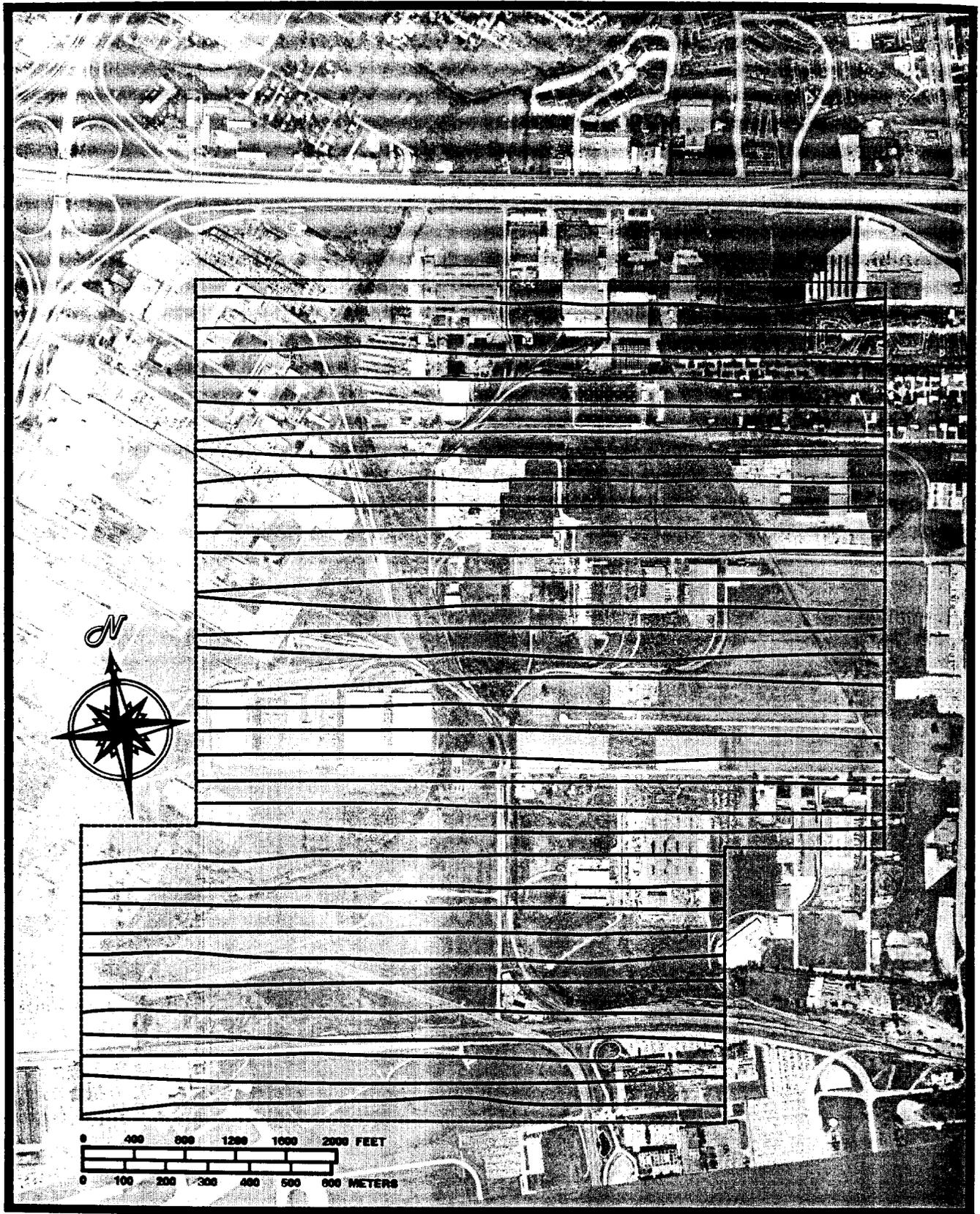


Figure 2. FLIGHT LINES: LATTY AVENUE

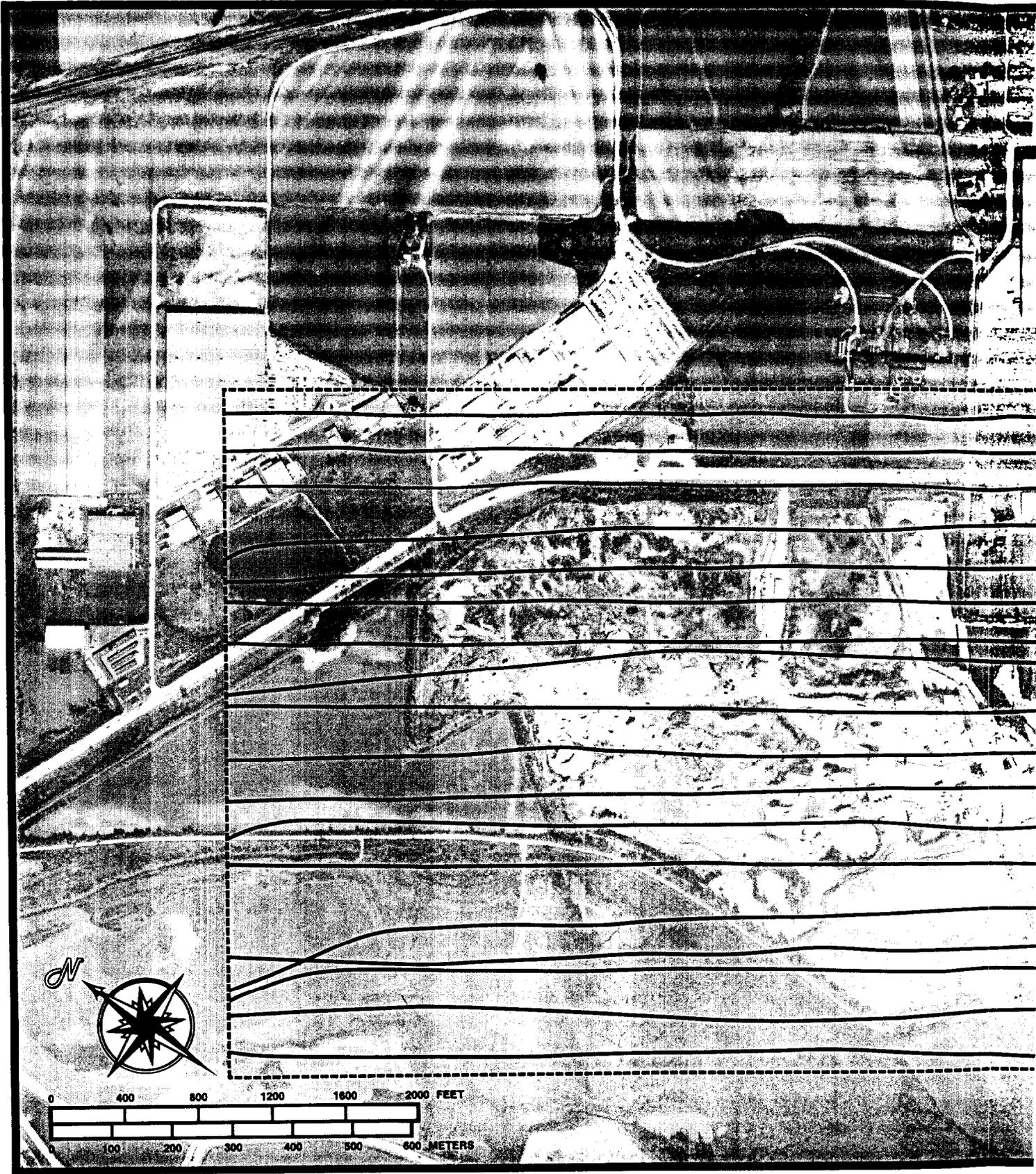


Figure 3. FLIGHT LINES: WEST LAKE LANDFILL



Figure 3. FLIGHT LINES: WEST LAKE LANDFILL

along the programmed flight lines on the photograph. The survey pattern consisted of parallel lines at 60 m intervals. Flight altitude was 60 m.

A Hughes H-500 helicopter was utilized for the survey (Figure 4). The H-500 carried a crew of two: pilot and navigator. The helicopter employed a lightweight version of the Radiation and Environmental Data Acquisition and Recorder system (REDAR). Two pods were mounted on the sides of the helicopter: each pod contained ten 12.7 cm diameter by 5.1 cm height NaI(Tl) detectors. Gamma ray signals from the 20 detectors were summed and routed through an analog-to-digital converter and a pulse-height analyzer. Gamma spectra were accumulated in 3-second intervals and recorded on 1/2 inch magnetic tape.

The helicopter position was established with two systems: a Trisponder/202A Microwave Ranging System (MRS), and an AL-101 radio altimeter. The trisponder master station

mounted in the helicopter interrogated two remote transceivers mounted on towers outside the survey area. By measuring the round trip propagation time between the master and remote stations, the master computed the distance to each. These distances were recorded on magnetic tape each second; in subsequent computer processing these were converted to position coordinates.

The radio altimeter similarly measured the time lag for the return of a pulsed signal and converted this to aircraft altitude. For altitudes up to 150 m, the accuracy was ± 0.6 m or $\pm 2\%$, whichever is greater. These data were also recorded on magnetic tape so that any variations in gamma signal strength caused by altitude fluctuation could be accurately compensated.

The detectors and electronic systems which accumulate and record the data are described only briefly here. They are described in considerable detail in a previous report.¹



Figure 4. HUGHES H-500 HELICOPTER CONTAINING THE REDAR SYSTEM

4.0 DATA PROCESSING

Data processing was done with the Radiation and Environmental Data Analyzer and Computer system (REDAC). This is a computer analysis laboratory mounted in a mobile van (Figure 5).

REDAC consists primarily of two Cipher Data tape drives, a Data General NOVA 840 computer, two Calcomp plotters, and a Tektronics CRT display screen. The computer has a 32 k-word core memory and an additional 1.2×10^6 -word disc memory. An extensive collection of software routines is available for data processing.

The gross count data were corrected for system dead time and altitude deviation. Corrections to the gross count rates were also made for contributions from radon, aircraft background,

and cosmic rays. Flights over the Missouri River were used for this purpose.

The corrected gross count rates were converted to exposure rates at 1 m altitude, with the factor 1024 counts per second (cps) per $\mu\text{R/h}$ obtained from calibration data over a Nevada test range.

5.0 DISCUSSION AND RESULTS

Analysis of the radiological data taken over the area surrounding each of the sites discussed in this report indicates that the terrestrial radioisotopes and associated gamma ray exposure rates were consistent with the natural background normally found within areas having a similar geological basis. These background exposure rates were in the 8-11 $\mu\text{R/h}$ range, including 3.7 $\mu\text{R/h}$ due to cosmic rays.

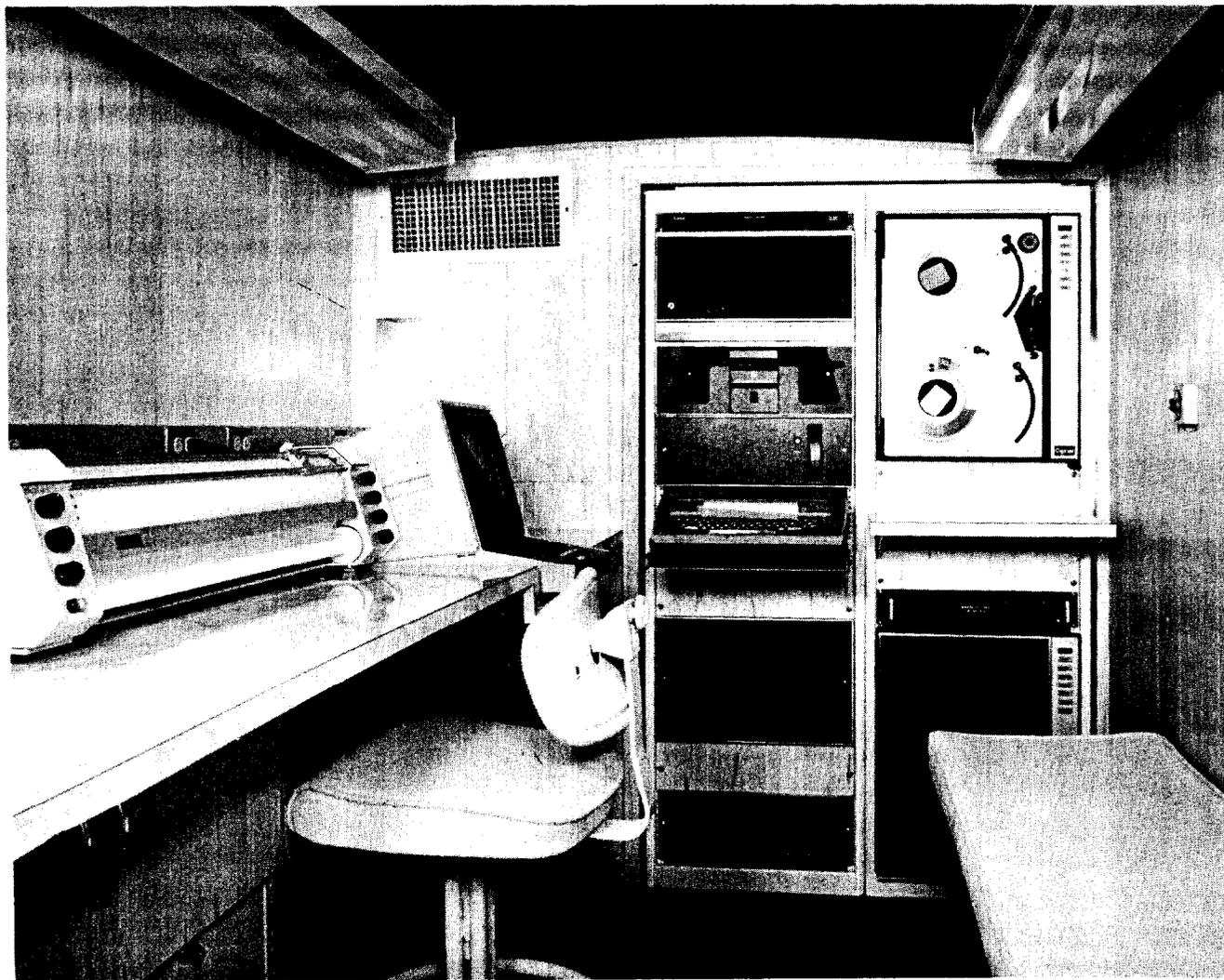


Figure 5. MOBILE COMPUTER PROCESSING LABORATORY

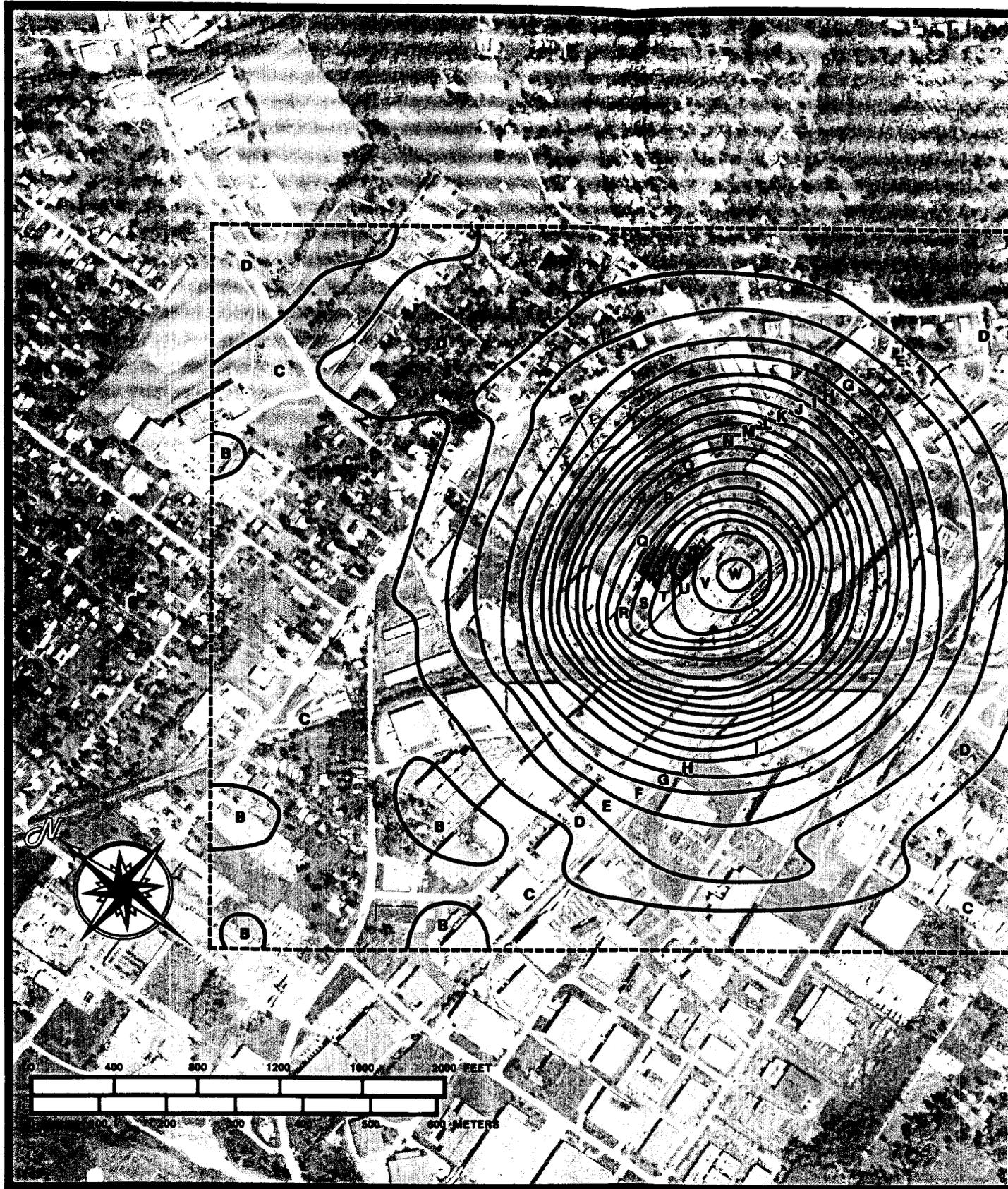
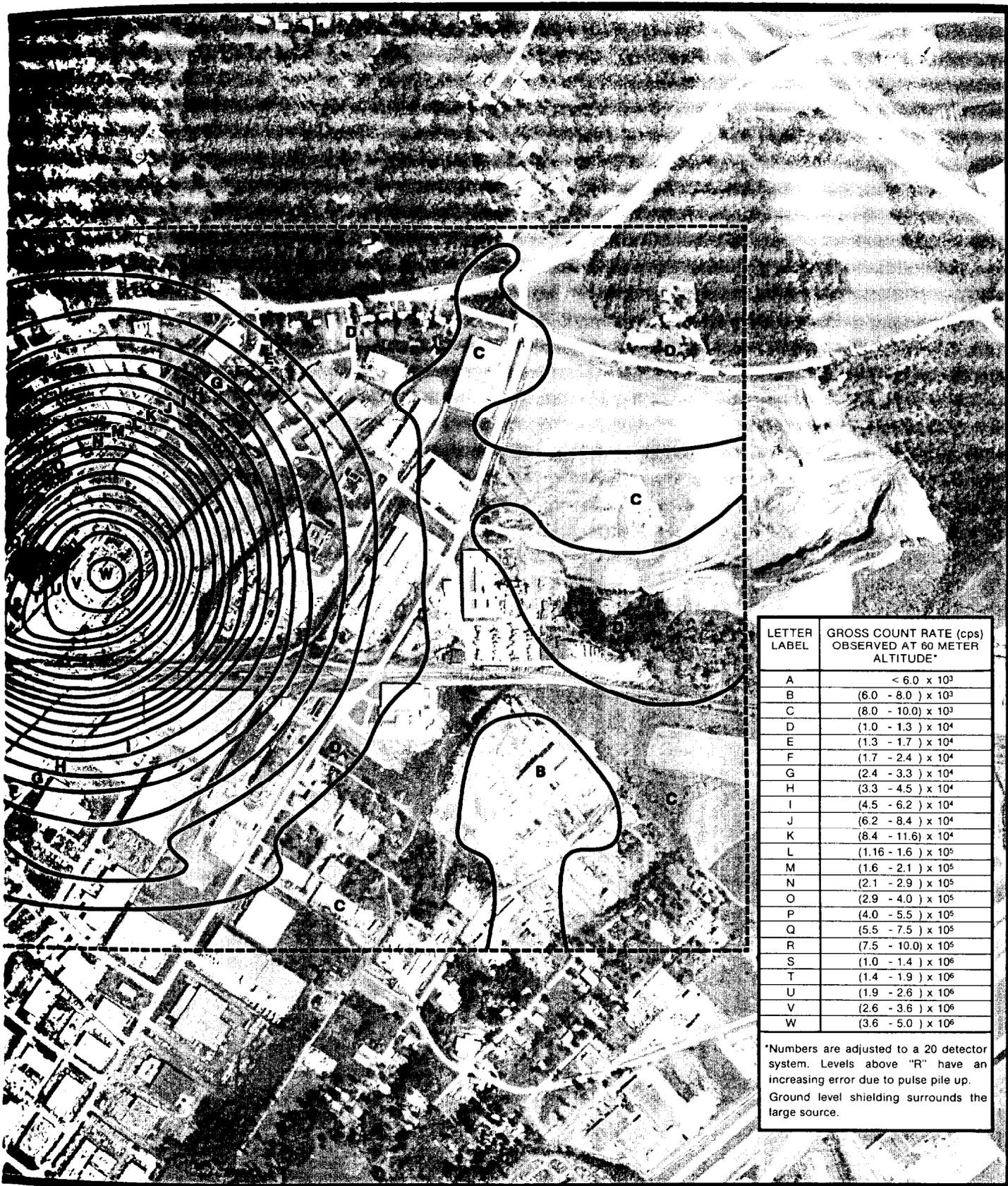


Figure 6. GROSS COUNT RATE ISOPLETHS: AERIAL DATA - MALLINCKF



LETTER LABEL	GROSS COUNT RATE (cps) OBSERVED AT 60 METER ALTITUDE*
A	< 6.0 x 10 ³
B	(6.0 - 8.0) x 10 ³
C	(8.0 - 10.0) x 10 ³
D	(1.0 - 1.3) x 10 ⁴
E	(1.3 - 1.7) x 10 ⁴
F	(1.7 - 2.4) x 10 ⁴
G	(2.4 - 3.3) x 10 ⁴
H	(3.3 - 4.5) x 10 ⁴
I	(4.5 - 6.2) x 10 ⁴
J	(6.2 - 8.4) x 10 ⁴
K	(8.4 - 11.6) x 10 ⁴
L	(1.16 - 1.6) x 10 ⁵
M	(1.6 - 2.1) x 10 ⁵
N	(2.1 - 2.9) x 10 ⁵
O	(2.9 - 4.0) x 10 ⁵
P	(4.0 - 5.5) x 10 ⁵
Q	(5.5 - 7.5) x 10 ⁵
R	(7.5 - 10.0) x 10 ⁵
S	(1.0 - 1.4) x 10 ⁶
T	(1.4 - 1.9) x 10 ⁶
U	(1.9 - 2.6) x 10 ⁶
V	(2.6 - 3.6) x 10 ⁶
W	(3.6 - 5.0) x 10 ⁶

*Numbers are adjusted to a 20 detector system. Levels above "R" have an increasing error due to pulse pile up. Ground level shielding surrounds the large source.

NT RATE ISOPLETHS: AERIAL DATA - MALLINCKRODT NUCLEAR SITE

5.1 Mallinckrodt Nuclear

Figure 6 presents gross count rate isopleths superimposed on an aerial photograph of the Mallinckrodt Nuclear Maryland Heights Facility. The isopleths shown in this figure are consistent with the existence of point sources in a storage room which has heavily shielded walls at the ground level but a lightly shielded roof. Due to this difference in shielding the aerially determined isopleths are not representative of what would be measured on the ground. For this

reason, and because conversion factors apply only to uniform horizontal distributions at the ground level, the letter labels in Figure 6 have not been converted to exposure rates at the 1 m level.

Figure 7 is a background-subtracted energy spectrum of the radiation from the area of increased activity. Photopeaks observed are 364 keV and 637 keV from ^{131}I , 740 keV and 780 keV from ^{99}Mo , and 1.095 MeV and 1.292 MeV from ^{59}Fe . All three of these isotopes are received by the Facility for processing.

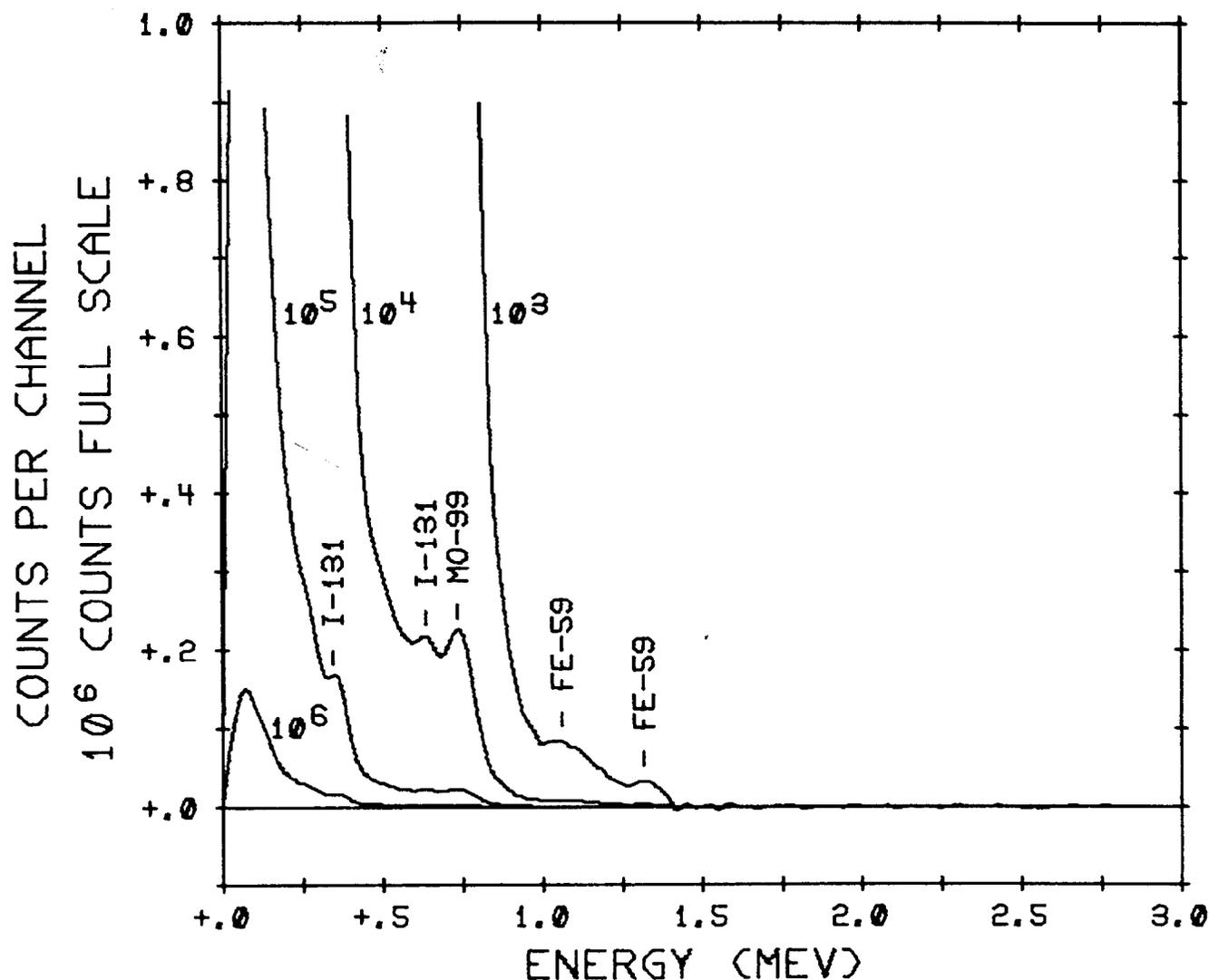


Figure 7. BACKGROUND-SUBTRACTED ENERGY SPECTRUM: MALLINCKRODT NUCLEAR SITE
This spectrum characterizes the enhanced activity observed in Figure 6.

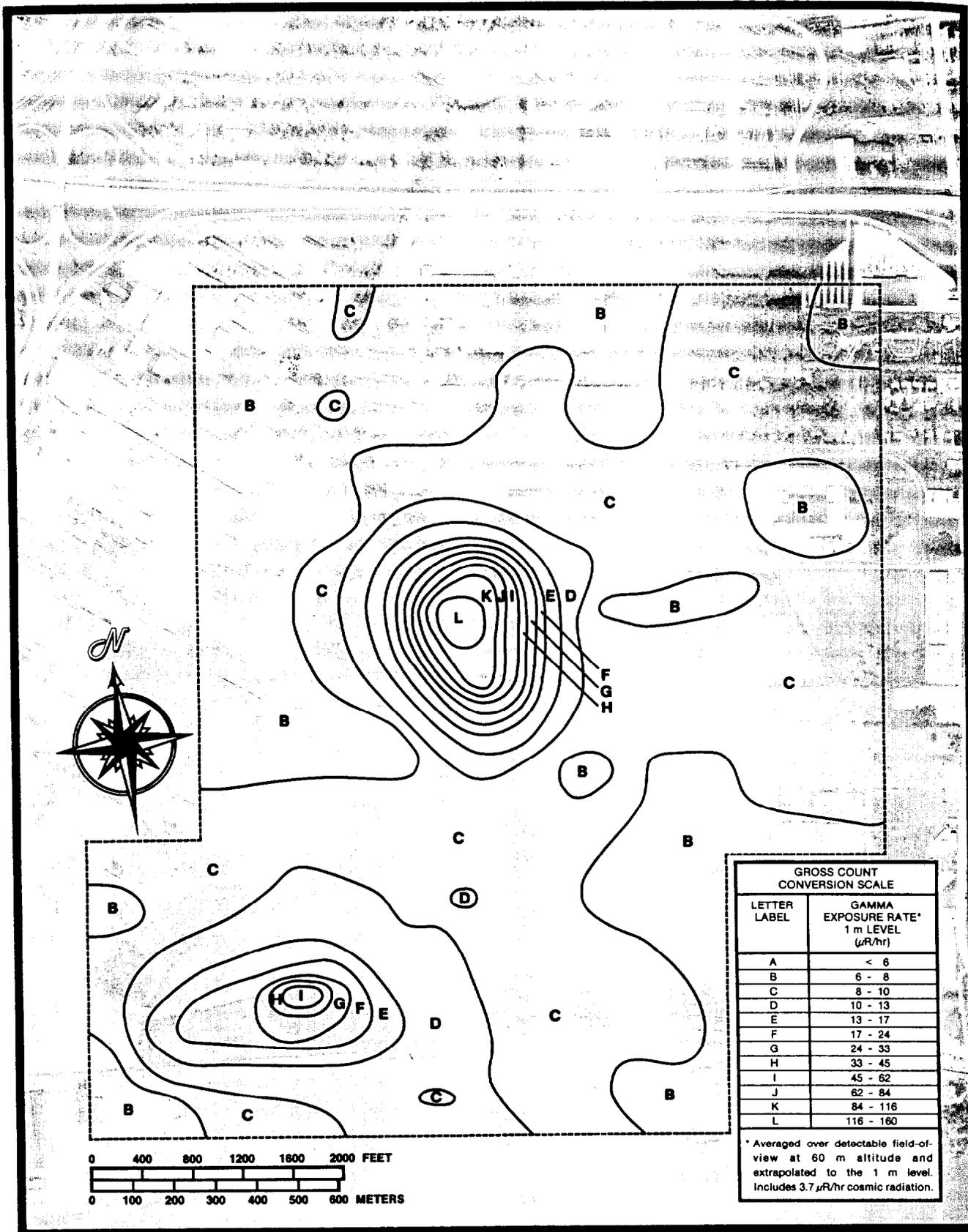


Figure 8. EXPOSURE RATE ISOPLETHS: LATTY AVENUE

5.2 Latty Avenue and Airport

Figure 8 presents the exposure rate isopleths superimposed on an aerial photograph of the site. Figure 9 is a background-subtracted energy spectrum of the radiation characteristics of both areas of increased activity. Radiation from ^{214}Bi accounts for all the major photopeaks observed.

This isopleth map (Figure 8) is based on gross counts (integral counts in the energy region

between .05 MeV and 3 MeV). The factor used to convert these counts to the exposure rate at the 1 m level was determined from measurements at a calibration site containing a typical mix of naturally occurring radionuclides. Since the spectrum shown in Figure 9 is different from a typical natural spectrum, the conversion factor may be in error. The isopleths, which represent ground level exposure rates for distributed sources, are consistent with sources whose lateral dimensions are a few hundred feet.

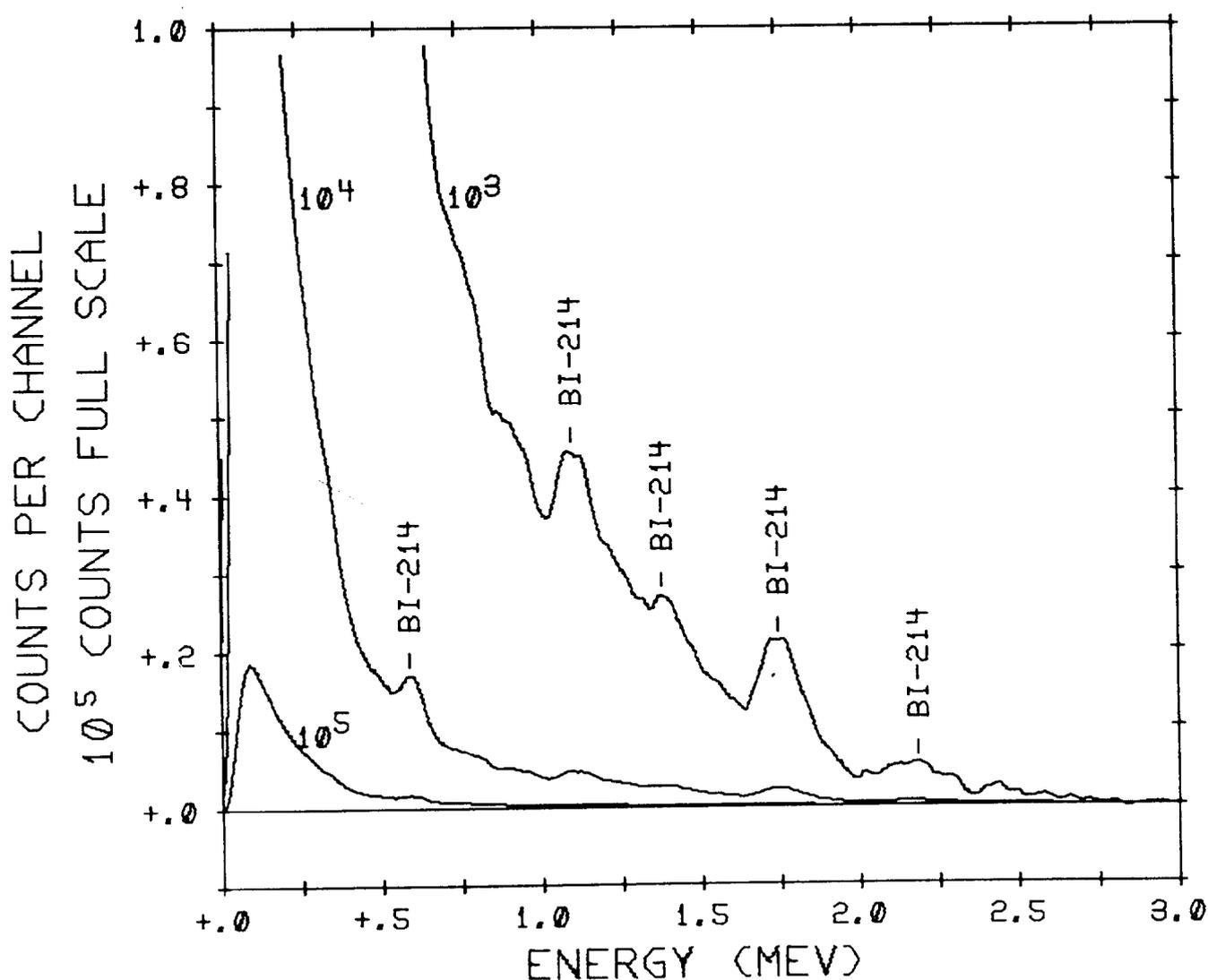


Figure 9. BACKGROUND-SUBTRACTED ENERGY SPECTRUM: LATTY AVENUE
 This spectrum of gamma radiation was characteristic of the areas of increased activity at Latty Avenue and the airport as shown in Figure 8.

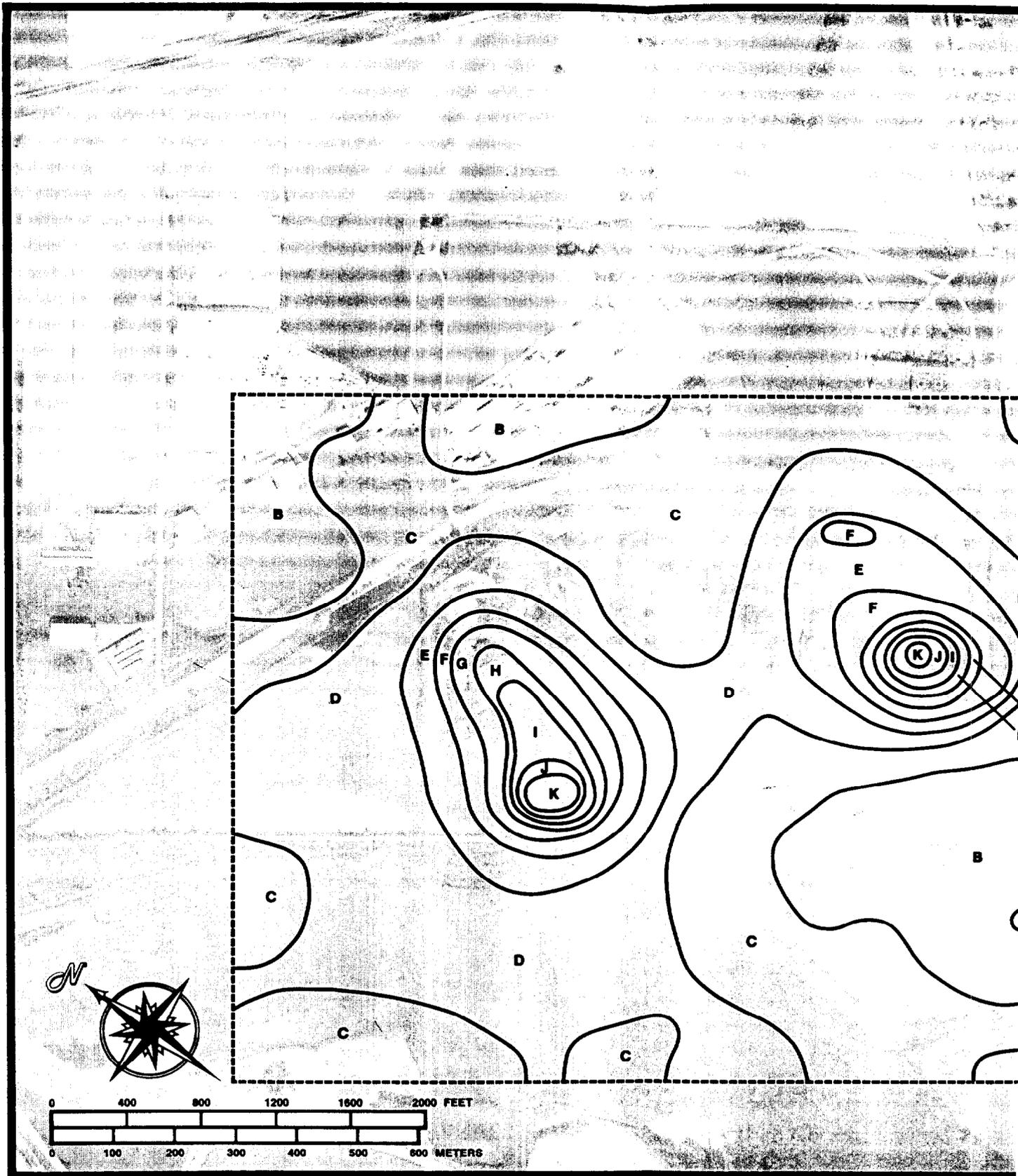


Figure 10. EXPOSURE RATE ISOPLETHS: WEST LAKE

GROSS COUNT CONVERSION SCALE	
LETTER LABEL	GAMMA EXPOSURE RATE* 1 m LEVEL (μ R/hr)
A	< 6
B	6 - 8
C	8 - 10
D	10 - 13
E	13 - 17
F	17 - 24
G	24 - 33
H	33 - 45
I	45 - 62
J	62 - 84
K	84 - 116

* Averaged over detectable field-of-view at 60 m altitude and extrapolated to the 1 m level. Includes 3.7 μ R/hr cosmic radiation.



Figure 10. EXPOSURE RATE ISOPLETHS. WEST LAKE LANDFILL

5.3 West Lake Landfill

Figure 10 presents the exposure rate isopleths superimposed on an aerial photograph of the site. Figure 11 is a background-subtracted

energy spectrum of the radiation characteristic of both areas of increased activity. Radiation from ^{214}Bi accounts for all the major photopeaks observed.

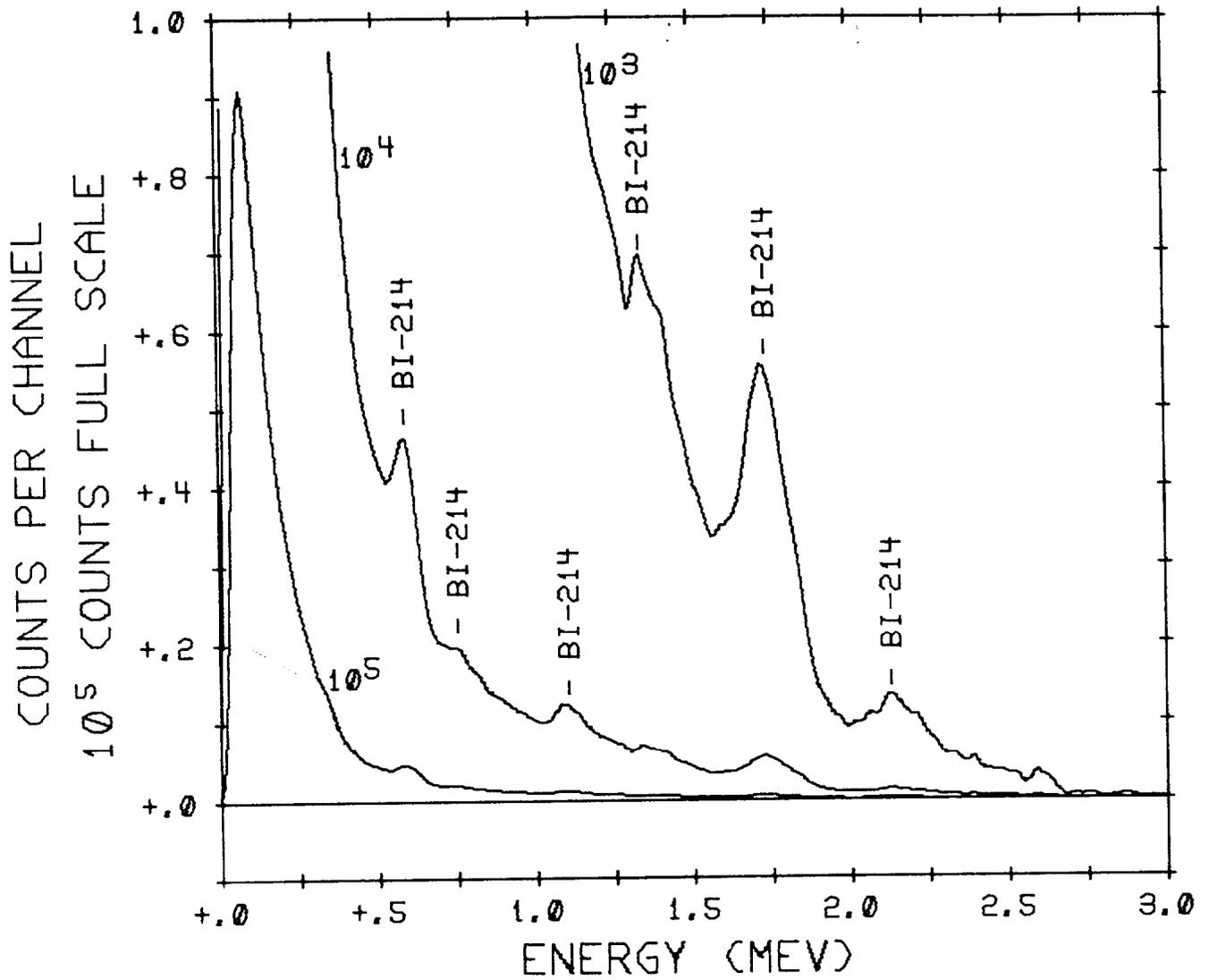


Figure 11. BACKGROUND-SUBTRACTED ENERGY SPECTRUM: WEST LAKE LANDFILL
Photopeaks shown here characterize both areas of enhanced activity in Figure 10.

1

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